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ABSTRACT

This study was developed to investigate differences between black and white freshmen (both men and women) entering engineering programs. Specifically the study determined the relationships between enjoyment of course studied, achievement in those courses, and persistence, as reported by black/white, male/female students entering the engineering curriculum. The study also determined which variables functioned as the best predictors of gender and ethnic origin. Subjects were 511 freshmen orientation students at a large southeastern university. Ten discriminating variables significantly predicting gender included: enjoys language, art/graphics, history, economics, and physics and had high grades in language, physics, history, arts/graphics, and chemistry. The four discriminating variables of ethnic origin were: high grades on languages, total score in persistence, enjoys economics, and high grades in physics. Black males reported significantly more persistence than white males, though the reverse was true for females. 18 references) (JDD)

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GENDER AND RACE DIFFERENCES IN ACHIEVEMENT,
ENJOYMENT OF ACADEMIC SUBJECTS AND PERSISTENCE IN FRESHMEN
ENGINEERING STUDENTS

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ABSTRACT

The under-representation of women and American blacks in engineering education merited the need for understanding group differences to facilitate programs for success. This study examined gender and race differences in engineering freshmen in enjoyment and level of achievement in 7 subjects, persistence and their inter-relationships. Subjects were 511 freshmen (32 black males, 22 black females, 357 white males and 100 white females) entering a large southeastern university. Multiple discriminant analysis successfully classified males and females with 77% accuracy ($R_c = .40$, Chi Sq. = 54.26, $df=4$, $p = .001$). A second multiple discriminant analysis classified black and white students with 89.4% accuracy ($R_c = .17$, Chi Sq. = 14.98, $df=4$, $p = .0047$). And a third analysis on the interaction of race by gender effects resulted in two significant multiple discriminant functions classifying 76.4% accurately. Differences in subjects were that males reported higher grades in Arts and graphics, history and physics. Females reported greater enjoyment of languages. Persistence was not a significant predictor of the main effect for gender however, graphed interaction effects show ordinal interaction for gender and race.

Background

Declining enrollments in engineering, math and sciences is an alarming national threat. The 1987 Freshmen Survey Report quote sharp declines in engineering of more than a fourth since 1982. In 1982 only 8.5 percent of the entering freshmen expressed interest in engineering careers, which was down from 9.7 in 1986 and well below 12.0 percent in 1982 (American Council on Education, 1987).

The social barriers to an engineering career for minorities have been criticized since the 1960's in terms of civil rights, however just removing institutional barriers has not truly opened doors for the vast majority of minorities (Garellick, 1980; Williams, 1990). Something else needs to be done to channel the great national wealth of intelligence into careers of engineering, math and the sciences.

A review of the literature revealed six areas which may become barriers to successful completion of an engineering degree: background variables; financial concerns; career awareness and maturity, sex stereotyped views that few women manage a career in engineering, or are able to master the math necessary for the degree; personality factors of locus of control, persistence, responsibility, self esteem, self-doubt and others; and finally, abilities in math and science (Ware, Steckler & Leserman, 1985; Swanson & Hansen, 1985; Eccles, 1986; Ivey, 1988; Metz & Campbell, 1987).

One national recruitment policy has been blamed for the leveling off of American blacks and women enrollments: using the SAT scores as entrance barriers (scores above 600 on the math test). Long disputed for being culturally biased against blacks, the SAT is also gender biased in its item

pool, 11% of the eligible women compared to 23% of the males scored above 600 on the SAT math test (College Board, 1985).

Another recruiting limitation is the difference in the amount of career information and encouragement given to young girls and boys (Daniels, 1987). Lack of understanding by young women of the influences of locus of control and other psychological factors, the expectation for success in relation to the amount of effort expended, the potential costs of investing time (Eccles, 1986). Peer pressure based on sex and race stereotyped opinions can greatly handicap women in making good career decisions (Adams, 1988; Daniels, 1988; Landis, 1988; Hazell, 1987; Baird, 1981; Iker, 1980).

American blacks have additional barriers which limit encouragement into engineering and the sciences. Rigid admissions and financial-aid procedures create unnecessary institutional barriers of blacks (Adams, 1988). In most schools the women and blacks who have been accepted into engineering are of the same academic quality as white males because the admission criteria are based on a standard formula (Humphreys, 1988). There are few schools which have engineering technology programs which can allow more flexible admissions standards and specialized undergraduate curricula for those who could become engineers but because of poor high school preparation can not compete with the entrance standards.

This study was developed to investigate differences between black and white freshmen (both men and women) entering engineering programs in order to facilitate the development of a model program to encourage future students to enroll in undergraduate engineering programs, to remain in engineering and to aspire to a graduate degree in engineering; and to work with students

throughout their undergraduate studies, providing mentoring and counseling services to overcome attitudes reported in this survey as barriers to study in engineering programs.

The purposes of this study were: a.) to determine the relationships between enjoyment of course studied, achievement in those courses and persistence as reported by black/white, male/female students entering the engineering curriculum, and b.) to determine which of the above variables function as the best predictors of gender and ethnic origin (black and white races).

Methods and Procedures

Instrument Development

The objective of the instrument was to define baseline information on students enrolling in engineering to facilitate development of a minorities program at a southeastern landgrant institution. Students were asked to complete the demographic information and to respond to a 24 item persistence scale (true/false) which has 3 subscales and measures the qualities of persistence as in persevering (determined), quitting, fickle as in getting discouraged (reversed) and play before work (reversed) attitudes (Derman, French & Harman, 1978). The total scale is scored so that summed items with a range of 0 to 24 represent a positive attribute of seeing a job through to the end. Subjects were also asked: What are three subjects you make high grades in?; arts/graphics, chemistry, economics, history, language, math, and physics. Each topic circled was coded a "1", topics not circled a "0". These seven high grade items were used as predictors in the discriminant analyses. Another question listed the same seven topics and asked: What are three

subjects you enjoy studying? The same coding was applied to each of the seven topics per person and used as enjoyment indices. Addition information was requested but not addressed in this study (Schaer, Aull, Pancake & Curtis, 1990). Names were requested for followup purposes with assurances that the information would be held confidential. Responses were computer coded and analyzed for reliability and for predictive validity using SPSS-X statistical package. Students with missing data were deleted from the analyses.

Subjects

Subjects were 511 (32 black males, 22 black females, 357 white males and 100 white females) freshmen orientation students enrolling in the College of Engineering, between the ages of 17 and 21. The students reported whether they had family members and who those family were. Less than .04% reported having mothers, aunts, sisters or other female relatives who are engineers. Males reported having fathers who are engineers (51%) and uncles (27%). Females (46%) had engineering fathers and uncles (21%). Male and female blacks reported only 31% having fathers with engineering degrees and 44% other family members as engineers who were not fathers, mothers, brother, sister, uncle or aunt. They did not write in this extended family relationship, and it is unclear how close the relationship was. Seventeen percent of all students indicated uncertain of their engineering specialization at that time and enrolled in a general pre-engineering curricula with out declaring a major. Aerospace, electrical, and mechanical engineering were the most frequent specified choices of 64% of all males whereas chemical, aerospace, computer and electrical engineering were the most frequent choices of the females (48%). Thirty-seven percent of all blacks chose electrical were equally split on aerospace (14%), computer (14%) and chemistry (14%).

Analysis and Results

Of particular interest in this study was the differences between gender and ethnic origin and persistence. The total persistence score was used to predict along with interest and achievement gender and ethnic origin. Internal consistency coefficient alpha for the total persistence score was .49 on this sample of 511 freshmen. The persistence total score was standardized so that means across gender and race could be compared.

Two of the variables of interest, enjoyment of subjects and highest grades were multi-nominal responses, coded as either "yes" or "no" (1,0). This limited the possibilities for analysis. Stepwise multiple discriminant analysis was chosen because it is the appropriate measure of nominal data measured on a 0 to 1 continuum when multiple measures are likely predictors of a categorical condition. In this study, the criteria, gender and ethnic origin also referred to race, were categorical with two discrete categories. Students were included in this study only if they indicated their ethnic origin was Afro-American or Caucasian. The interaction between gender and ethnic origin was another possible source of variation. Multivariate analysis variance could not be used in this study because of multi-nominal variables of multi-response nature. In other words the enjoyment and highest grades in subjects variables could not be combined to form a total score. Preliminary models showed significant predictive ability by a combination of enjoyment and highest grades on gender and race. Therefore the interaction of gender and race was created by creating a 4 level categorical variable combining gender and race. This model resulted in two significant discriminant functions correctly classifying black males, black females, white females and white

males with 70% accuracy. Table 1 shows the means and standard deviations of each category for each of the predictor variables. When a profile of the means for each category is plotted, the interactions are both ordinal and disordinal (Figure 1). The persistence total score was of special interest. The higher the score the more persistence a person is likely to have. In this study, males scored both highest and lowest with black males reporting significantly more persistence than white males. The ordinal interaction caused by a reverse in the female scores by race washed out the main effect for gender on persistence.

Table 3 shows which predictors contributed to the significant interaction and the importance of each contributing of predictor (Structure coefficients) in the set of predictors.

In order to understand how males differ from females and blacks from whites, separate main effect models were repeated on each with the same predictors entered in the stepwise discriminant models. A significant discriminant function (Canonical Correlation = .34, Chi Square = 64.12, 10 df, $p < .01$) was found for the total model which successfully classified 76.42% of the 511 students into appropriate gender. Another significant discriminant function (Canonical Correlation = .17, Chi Square = 14.98, 4 df, $p < .01$) was found for the total model which successfully classified 87.43% of the 511 students into appropriate ethnic origin.

Whereas 10 variables contributed in discriminating between males and females, only four variables discriminated between race. The ten discriminating variables significantly predicting gender shown in Table 2 were: Enjoys language, art/graphics, history, economics and physics, high grades in language, physics, history, arts/graphics and chemistry. The

4 discriminating variables of ethnic origin were: High grades in languages, persistence total score, enjoys economics and high grades in physics.

The plotted means for males and females of both races show very similar profiles. When the profiles are overlaid, the greatest deviations between the four categories in the areas that are most critical for engineering students are the persistence score and high grades in chemistry which are higher for black males and lower for black females than all other groups. Females of both groups rank lower in enjoyment of history than all males, but this could be a reflection on the fact that history has been written for men, by men, and females simply find little enjoyment in those confines. Otherwise males and females of both races in this study have very similar profiles of subject enjoyment, and achievement.

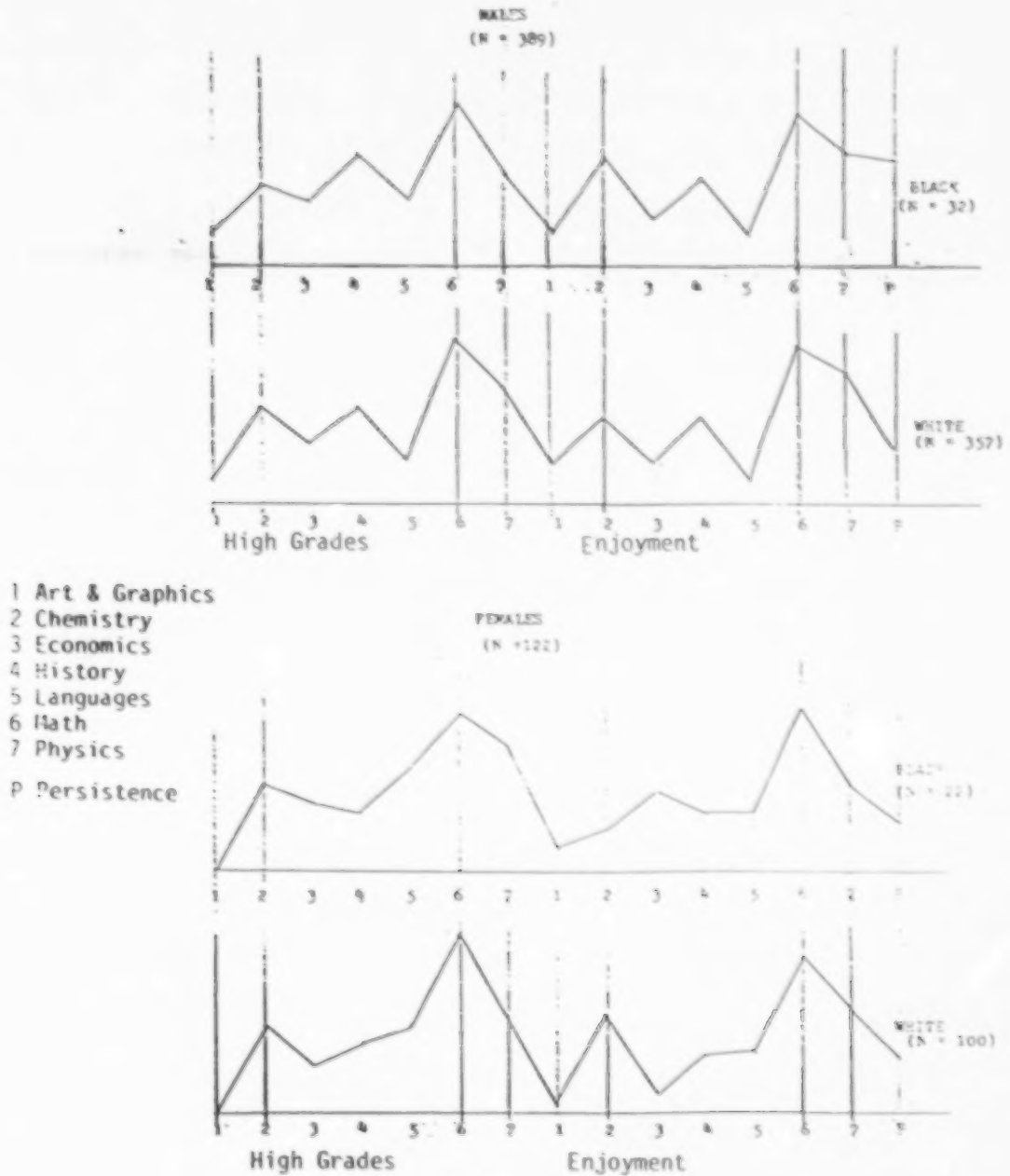
Implications

These data are descriptive of the men and women of the two prominent races, black and white, entering this engineering school as freshmen. Knowing the nature of these students can help counselors and high school teachers encourage others to enroll in engineering. Although this study does not define those who graduate from engineering, this data is a part of an ongoing study investigating variables of importance in retention and attrition in engineering. The lack of significance in the persistence variable for white males and females is useful information when defining attrition rates over all engineering schools which nationally report more females than males drop out even though grade point averages are higher for females (Garelick, 1980). This statistic is not yet available for this institution but is a high priority for future research.

FIGURE 1

PROFILES OF BLACK MALES, WHITE MALES, BLACK FEMALES AND WHITE FEMALES

MEANS ON HIGH GRADES AND ENJOYMENT IN SUBJECTS AND PERSISTENCE



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TABLE 1
MEANS AND STANDARD DEVIATIONS OF ALL PREDICTORS
BY RACE BY GENDER N=511 FRESHMEN

Predictor	BLACKS				WHITES				TOTAL	
	<u>Males</u>		<u>Females</u>		<u>Males</u>		<u>Females</u>		—	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
Highest Grade in:										
Arts/Graphic	.16	.37	.05	.21	.12	.33	.05	.22	.11	.31
Chemistry	.41	.50	.45	.51	.47	.50	.44	.50	.46	.50
Economics	.34	.48	.36	.49	.30	.46	.24	.43	.29	.46
History	.56	.50	.32	.48	.48	.50	.39	.50	.46	.50
Language	.34	.48	.55	.51	.22	.42	.43	.50	.28	.45
Math	.81	.40	.82	.39	.82	.39	.83	.38	.82	.38
Physics	.47	.51	.36	.49	.57	.49	.45	.50	.53	.50
Enjoyment in:										
Arts/Graphic	.19	.40	.14	.35	.20	.40	.09	.29	.17	.38
Chemistry	.56	.50	.23	.43	.43	.50	.52	.50	.45	.50
Economics	.25	.44	.41	.50	.22	.42	.15	.36	.22	.41
History	.44	.50	.32	.48	.44	.50	.31	.46	.41	.49
Language	.16	.37	.32	.48	.11	.32	.32	.47	.17	.37
Math	.78	.42	.82	.39	.80	.40	.87	.34	.82	.39
Physics	.56	.50	.50	.51	.67	.47	.55	.50	.63	.48
Persistence Total	16.38	3.32	16.14	2.20	15.33	3.16	15.55	3.05	15.48	3.12

TABLE 2

MULTIPLE DISCRIMINANT ANALYSIS SUMMARY OF PREDICTORS OF
INTERACTION EFFECT, RACE AND GENDER MAIN EFFECTS

Predictors of Race by Gender Effect

Function	Can. Corr.	Wilk's Lambda	Chi- Sq.	d.f.	Signif.	Cumulative % Variance		
1	.33	.84	88.5	30	.0000	67		
2	.20	.94	30.0	18	.0377	89		
3	.14	.98	10.3	8	.2473	100		

Functions	Inclusion Order	Wilk's Lambda	Standardized Coefficients			Structure Coefficients		
			1**	2*	3	1**	2*	3
Enjoys Language	1	.95**	-.49	.27	-.22	-.68*	.03	-.12
Enjoys Chemistry	2	.93**	-.22	1.01	.36	-.07	.63*	.08
High Grade Language	3	.91**	-.35	-.20	.42	-.64*	-.13	.29
Enjoys Math	4	.90**	-.22	.23	-.03	-.17	-.08	-.24*
High Grade Chemistry	5	.89**	.21	-.56	-.10	.06	-.08	-.15*
Enjoys Economics	6	.88**	.01	-.29	.52	.06	-.52*	.44
Persistence Total	7	.87**	-.13	-.05	-.61	-.14	-.02	.56*
High Grade History	8	.86**	.41	.40	.36	.24*	.21	.30*
High Grade Physics	9	.85**	.47	.15	.01	.35*	.07	-.27
High Grade Arts/Grap.	10	.84**	.35	.20	.39	.28	.08	.30*
High Grade Math						-.15	-.02	-.25*
Enjoys Art & Graphics						.18	-.07	.15
Enjoy History						.19	-.05	.05
Enjoys Physics						.31	-.03	-.18
High Grade Economics						-.01	-.14*	.11

70.5% Correctly Classified

TABLE 2 (continued)

Predictors of Race Effect

Function	Can. Corr.	Wilk's Lambda	Chi- Sq.	d.f.	Signif.
1	.17	.97	14.98	4	.005
	Inclusion Order	Wilk's Lambda	Standardized Coefficients	Structure Coefficients	
Functions			1	1	
High Grade Language	1	.99**	.60	.63	
Persistence Total	2	.98**	.56	.51	
Enjoys Economics	3	.97**	.45	.46	
High Grade Physics	4	.97**	-.29	-.43	
Enjoys Physics				-.31	
Enjoys History				-.01	
High Grade Arts & Grap.				-.01	
Enjoys Languages				.29	
Enjoys Math				-.31	
High Grade Chemistry				-.16	
High Grade Math				-.13	
Enjoys Art & Graphics				.01	
Enjoys History				-.01	
Enjoys Chemistry				-.16	
High Grade Economics				.13	

 89.4% Correctly Classified

TABLE 2 (continued)

Predictors of Gender Effect

Function	Can. Corr.	Wilk's Lambda	Chi- Sq.	d.f.	Signif.
1	.34	.88	63.90	10	.0000
	Inclusion Order	Wilk's Lambda	Standardized Coefficients	Structure Coefficients	
Functions			1	1	
Enjoys Language	1	.95**	-.37	-.66	
Enjoys Arts & Graph.	2	.93**	.34	.32	
High Grade Language	3	.92**	-.23	-.56	
Enjoys History	4	.91**	.35	.30	
High Grade Physics	5	.90**	.43	.31	
High Grade History	6	.89**	.37	.29	
High Grade Arts & Grap.	7	.89**	.25	.30	
Enjoys Economics	8	.89**	.23	.09	
Enjoys Physics	9	.89**	.24	.31	
High Grade Chemistry	10	.88**	.17	.00	
High Grade Math				-.15	
Enjoys Chemistry				-.11	
Enjoys Math				-.16	
High Grade Economics				.00	
Persistence Total Score				.01	

76.4% Correctly Classified

* $p < .05$, ** $p < .01$

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